



SALT CONTAMINATION OF PRIVATE WELL SUPPLIES

Township of Gloucester
Lot 21, Concession 4

1974



Ontario

Ministry
of the
Environment

The Honourable
William G. Newman,
Minister

Everett Biggs,
Deputy Minister

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MINISTRY OF THE ENVIRONMENT

TOWNSHIP OF GLOUCESTER

LOT 21, CONCESSION 4

SALT CONTAMINATION OF PRIVATE WELL SUPPLIES

F. R. Campbell

1974

MINISTRY OF THE ENVIRONMENT

TOWNSHIP OF GLOUCESTER - LOT 21, CONCESSION 4
SALT CONTAMINATION OF PRIVATE WELL SUPPLIES

INTRODUCTION

In response to requests from Mr. R. J. Boswell, Director of Planning and Works, Township of Gloucester, and local residents, a study was initiated in June, 1972 by the Water Quantity Management Branch to determine the cause and extent of salt contamination in private wells in the vicinity of Lot 26, Concession 4, Township of Gloucester. Locally the problem was reported to coincide with severe blasting associated with the commencement of limestone quarrying operations at the nearby Bertrand and Frere Construction Company Ltd. quarry.

The study has included an examination of well records on file for the area, a review of geological and hydrogeological reports for the area and a search through other pertinent literature dealing with ground water contamination. Because of the complexities encountered several field examinations of the problem area were undertaken. These included interviews with the local residents and government and industry representatives, an examination of local topographic and geologic features and the sampling of a number of private and industrial wells for chemical analyses. The location of wells in the area and the analyses results of the above mentioned sampling programs are shown in Figure 1 and Table 1, respectively.

Background

A letter from Mr. W. Theelen, a local resident, was received by this Ministry in which an outline was given of the local well-water quality problem. Mr. Theelen stated that his well, which was drilled in 1960, began yielding poor quality salty water in June 1971. Prior to this time, the well water had been of acceptable quality. Mr. Theelen associated the change in quality with the commencement of blasting activity in the nearby Bertrand quarry. He also suggested that

four of his neighbours' wells were also producing poor quality water.

Prior to inquiries to this Ministry, Mr. L. Primeau, an official of the Township of Gloucester, had approached Mr. O. H. Bjarnason, District Engineer of the Division of Mines of the Ministry of Natural Resources as to the nature of the blasting activities at the Bertrand and Frere Construction Company Ltd. quarry. Mr. Bjarnason reported that the blast referred to was initiated "at 4:30 p.m. on May 10th, in their new quarry located on Lot 26, Concession V at the end of the Doncaster Road extension. They blasted 88 - 3" holes, 30 feet deep, drilled on 8 ft. x 8 ft. pattern, and used 6150# of explosives to break 13,400 tons of rock, with #0 to #8 short period delay caps. The holes were loaded to within 2 ft. of the collar and stemmed or filled with drill cuttings. The weather was clear, S.W. wind at 2 M.P.H. with an unlimited ceiling.

"This information was provided by Mr. R. J. Cliff, Manager of Bertrand's and taken from their blasting reports. This is the largest blast they had made in this quarry to date. Although weather conditions were considered ideal, the plants or industries N.E. of the quarry may have been affected by concussion, due to the light S.W. wind.

"The effects of concussion were thoroughly discussed and controls were recommended, such as (a) reducing the size of the blast, (b) providing more cushion, by not loading too close to the collars, (c) using more delays or blasting less holes per delay, and (d) blasting when weather conditions are favourable. Complete weather reports, including height of ceiling, may be obtained from the Canadian Forces Base at Uplands.

"These people are quite conscious of the effects of concussion and I am sure they will take the necessary precautions".

GEOLOGY

The study area is located approximately 8 miles south of Ottawa

on Highway 31. The bedrock geology is complicated because of the presence of the Gloucester fault to the immediate east of the area. East of the fault the bedrock comprises grey shale and some dolomite of the Carlsbad formation. Westward from the fault the sequence of bedrock at surface includes sandstone of the Nepean formation, grey calcareous sandstone and dolomite of the March formation, and grey limestone and dolomite of the Oxford formation.

The overburden materials include loam soils developed on clay tills and shallow loam soils developed on limestone bedrock. There are large areas of bare rock locally, while other soils are up to 20 feet in thickness. The soils are generally well drained and flat lying to gently undulating.

The study area is topographically high and thus surficial gradients locally tend to be in all directions away from the center of the area.

HYDROGEOLOGY

The Carlsbad formation, comprising shales, forms a poor aquifer with specific capacities of wells varying from 0.1 to 0.5 gpm. Aquifers in this formation frequently yield salty and sulphurous water and occasionally gas.

The Nepean sandstone on the other hand, is known to be a high capacity aquifer in the study area. Specific capacities of wells vary from 0.1 to about 14 gpm per foot of drawdown. About 70 per cent of the large diameter wells that penetrate 100 feet or more of the Nepean formation can be expected to yield in excess of 100 gpm. The water from this formation is generally fresh, but rare occurrences of sulphurous water are known.

Aquifer development in the March and Oxford formations is highly variable. Theoretical yields of wells vary from less than 10 gpm to greater than 100 gpm. On the average, it appears that wells with

yields of up to 50 gpm could be developed in the Oxford formation. Water from this formation is generally fresh, but may be sulphurous. Poor quality water is occasionally encountered in ground-water discharge areas and in the eastern half of the Township of Osgoode. North west of the study area, salty water is obtained from these formations when they are overlain by thick marine clays.

In the bedrock aquifers in the study area, ground waters tend to flow primarily through fractures under the influence of gravity from topographically high areas toward discharge in topographically low areas. Thus flow would be expected to be radially away from the center of the study area as shown in Figure 1. This flow pattern could be altered locally by large capacity wells and/or the presence of deep quarries under dewatering conditions.

Mr. Theelen, in an attempt to find a potable water supply, dug a shallow overburden well, the location of which is shown in Figure 1. The local overburden, which is about 10 feet in thickness, was partially saturated and yielded sufficient water for domestic purposes. In overburden aquifers, the configuration of the potentiometric surface generally conforms to topography. Thus local ground-water flow in this semi-confined unconsolidated aquifer would be expected to be in a southerly direction.

WATER QUALITY

A series of well-water samples was collected to determine the dissolved mineral content of waters and identify quality variations according to sources. The samples were analyzed for specific conductance, total hardness, alkalinity, chloride, sulphate, iron calcium, magnesium, sodium, potassium, ammonia, kjeldahl-nitrogen and nitrate- and nitrite-nitrogen. The analytical results of these samples are shown in Table 1. The chloride ion reflects the degree of saltiness in water. The preferred maximum in drinking water is 250 ppm.

From an examination of the results in Table 1, it is evident that the shallow bedrock wells of Theelen, Dolson, Cruikshank and Larocque have extremely high concentrations of chloride, (Cl), upto 7585 ppm with an average concentration of 4020 ppm. This contrasts sharply with concentrations of 91, 67 and 221 ppm Cl in other local wells in overburden aquifers sandstone aquifers and limestone aquifers, respectively.

Several potential sources of Cl were considered when dealing with aquifer contamination in the study area. These included natural sources of chloride within the bedrock, septic tank effluents, discharge of industrial wastes with high chloride concentrations, and finally the introduction of salt to the aquifer through road salt spreading or salt storage activities.

Piper Plot

Chemical quality variations are more readily seen when plotted in graphical form. A Piper Plot (Figure 2) is a trilinear diagram which illustrates the percentages as epm (equivalent per million) of major anions and cations in the water samples. Anions and cations are shown separately in two triangular fields and are combined in a diamond-shaped field. Trilinear diagrams are useful in pointing up differences and similarities between the chemistry of waters. Mixtures of two different waters will plot as points on a straight line between end points which represent the two water types.

A Piper Plot, Figure 2, was prepared from the analytical results for well water samples collected on August 23, 1972. The data for the plot are presented in Table 2. Straight lines can be drawn from the shallow limestone aquifer waters to the contaminated well waters as shown in Figure 2. Extending these straight lines to the vertices of the triangles in the diagram indicates by their position

that the contaminant is a sodium chloride (NaCl) water. Thus, water containing high concentrations of sodium chloride has presumably entered the shallow limestone aquifer, mixed with the normal aquifer water and produced the contaminated water observed in the affected wells.

ION EXCHANGE REACTIONS

The data for the affected wells shows an increase in calcium and magnesium concentrations as well as an increase in the NaCl concentration over normal background waters. Increased hardness concentrations were also experienced during the sampling period. Within analytical error, it can be demonstrated that the increases of calcium, magnesium, potassium and hardness in the affected well waters are due to ion exchange reactions between sodium ions introduced with the salt and calcium, magnesium and potassium ions which are normally absorbed on soil materials.

SOURCES OF SALT CONTAMINANT

Natural Occurrence of Sodium Chloride

Chlorides are widely distributed in natural waters, but generally the concentrations are small. Rainwater has an average concentration of only a few tenths of a ppm. Surface streams generally have chloride concentrations of a few tens of ppm. Water quality data compiled by the Water Quantity Management Branch indicate that naturally occurring concentrations of chloride in the bedrock aquifers in the study area west of the Gloucester Fault are low.

All natural waters contain measurable amounts of sodium. Natural concentrations range from about 0.2 ppm in rain and snow to more than 100,000 ppm in the brines from very deep bedrock formations. Analysis for sodium in water is seldom performed on a routine basis; hence, the only regional data on sodium concentrations in the aquifers in the area were collected during this study. It appears, as would be expected from the data in Table 2, that the natural sodium content of

local ground water is low in the 50 ppm range.

Septic Tank Effluents

Septic tank effluents may be suspected as a source of NaCl. However, septic tank effluents seldom contain greater than 80 ppm Cl, and therefore, could not produce chloride concentrations of up to 7585 ppm, as observed in the Laroque well. It has been the experience of the Ministry that aquifers which have been polluted with septic tank effluents rarely have increases of chloride concentrations that exceed 10 ppm.

Industrial Sources

There are no known industrial sources of salt in the sandy area.

Road Salting and Salt Storage

There are no known salt storage facilities in the study area.

Road salting activity in the area is reasonably intense at the intersection of Highway 31 and the concession road leading to the industrial park in the eastern section of the study area. An estimate of 500 to 700 pounds of salt per road mile per spread is applied to the roads with more salt being applied at the intersection itself particularly during severe ice conditions.

Quality Criteria of Sodium and Chloride in Water

Restrictions on chloride concentrations in drinking water are generally based on palatability rather than on health factors. The maximum recommended limit for chloride in water supplies in Ontario is 250 ppm (OWRC Guidelines for Water Quality Management in Ontario 1970). Chloride in water can be tasted by most people at a concentration level of 550 ppm. Water containing more than 500 ppm may be unpalatable and cause appetite disturbances. Although an excess of chloride induces thirst or can act as a diuretic, water containing up to 1400 ppm has

reportedly been used by some communities for many years without appreciable harm. In addition to the palatability and the possible hazard to health, chlorides are strong contributors to the rate of corrosion of metals.

Some writers have indicated that sodium concentrations in excess of 200 ppm in drinking waters may be harmful to persons suffering from cardiac, renal and circulatory diseases. It has been reported that drinking water of good quality may contain up to 115 ppm Na, although others have recommended a limit of 10 ppm as being desirable.

SUMMARY AND CONCLUSIONS

Salty water has suddenly been experienced in four shallow limestone bedrock wells in a confined area in the Township of Gloucester. Prior to the spring of 1971, no reported well water quality problem had been reported to have occurred in the study area. Local residents believe that with the commencement of blasting activity in a nearby quarry, aquifer water quality was affected rendering the water unfit for human consumption.

The affected wells obtain water at depths up to 60 feet from limestone bedrock of the Oxford formation. Other wells in the study area obtain water from the underlying Nepean formation. Both of these formations are known to yield good quality water in the study area. The Carlsbad formation, which lies in the eastern extreme of the area, across the hydraulically sealed Gloucester fault, does yield salty, sulphurous and/or gassey water, but no communication of this water to wells across and adjacent to the fault appears to have taken place.

The affected wells are located on a topographically high area and ground-water discharge would take place in a direction away from the wells. Thus it is expected that the source of the contaminant would be found close to the affected wells.

It has been shown that the contaminant is sodium chloride with

average concentrations of Cl being over 40 times that in other wells obtaining water from the same bedrock formation in the area. The natural concentration of sodium chloride in aquifers in the area is low. The only known source of sodium chloride in the area is the salting of nearby roads. With concentrations of Cl in the affected wells reaching 7000 ppm, the water is not only unpalatable but also it may be harmful to drink.

Water quality in the vicinity of the Bertrand quarry is excellent. The affected wells therefore cannot be obtaining poor quality water from aquifers near the quarry. The opinion that blasting activity has affected the aquifer quality of a few relatively distant wells without affecting other surrounding wells cannot be supported. It appears more likely that a source of salt unique to the area of the affected wells has contaminated a local area of the shallow bedrock aquifer. Such a source of salt may be the heavy salting of the intersection of Highway 31 and the concession road leading to the industrial park.

ALTERNATIVE SOURCES OF SUPPLY

Several alternatives are available to the affected parties in their efforts to obtain good quality drinking water. These include,

- 1) drilling to depth in the bedrock to obtain supplies from uncontaminated aquifers. This alternative has been successfully employed by Mr. F. E. Johnston locally. During drilling, it would be imperative to grout and seal off any upper contaminated zones to prevent the vertical migration of salty water down the well bore.

- 2) digging a shallow well in the unconsolidated overburden material may provide domestic supplies of contaminant free water. This alternative has been successfully employed by Mr. W. Theelen locally.

- 3) hauling of water to the affected residences.

RECOMMENDATIONS

It is recommended that,

1) consideration be given to the use of reduced salting techniques by Ministry of Transportation and Communications representatives in the affected area.

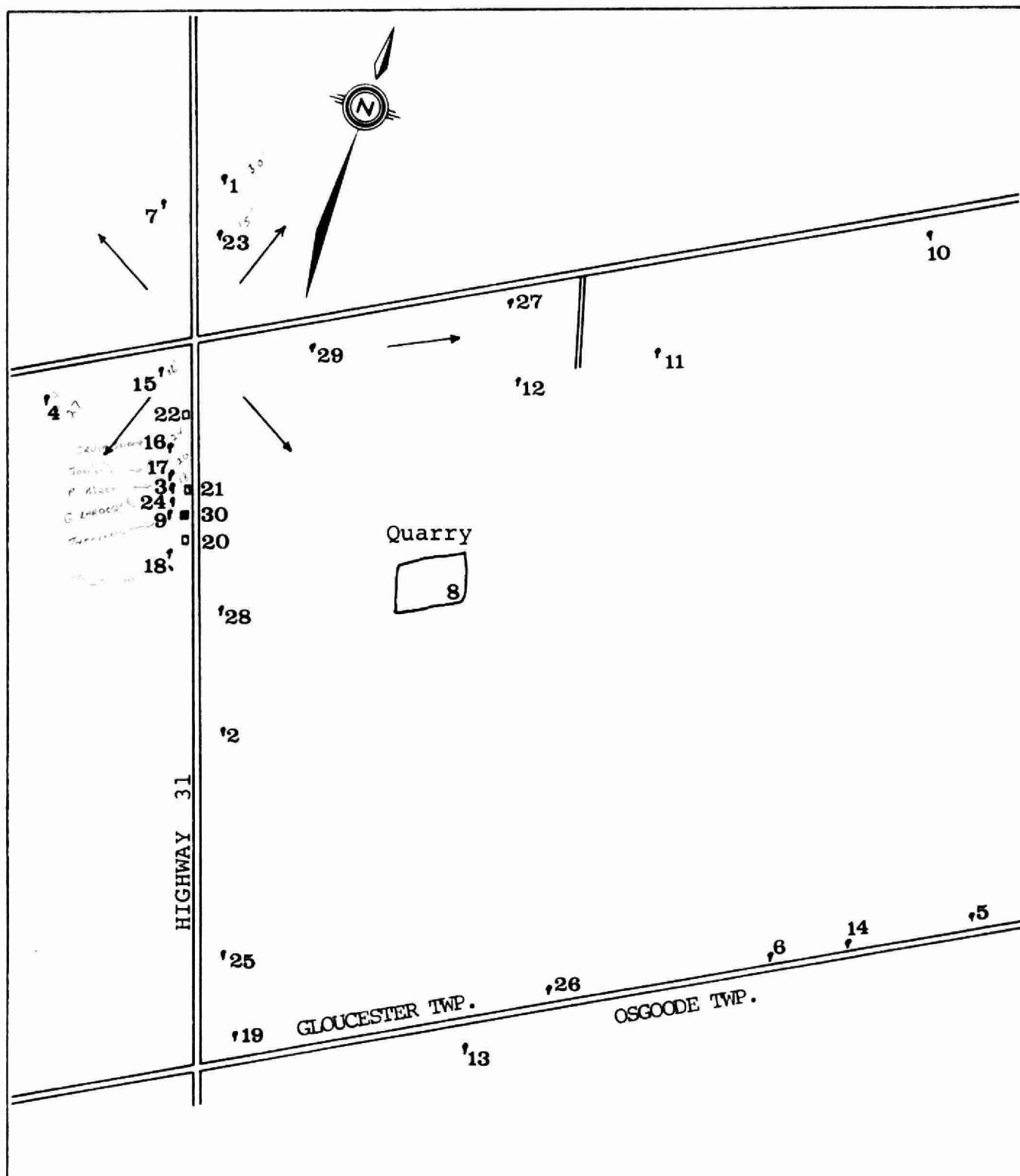
2) the Medical Officer of Health advise residents of the advisability of the use of the affected well waters for domestic use.

Report by:


F. R. Campbell, Hydrogeologist,
Hydrology and Monitoring Section,
Water Resources Branch.

FRC/af

16/4/74



LEGEND

- ↖ ANTICIPATED DIRECTION OF GROUND WATER FLOW IN BEDROCK AQUIFERS
- OVERBURDEN WELL
- ▼ BEDROCK WELL
- TEST HOLE

MINISTRY OF THE ENVIRONMENT
Water Quantity Management Branch

TOWNSHIP OF GLOUCESTER

Chloride Contamination

Of

Private Water Wells

Date: 23/3/74

Scale:

Drawing No:

Prepared by: D.L.

1" - 1500'

Figure 1



GB-32
Triangular - Co - Ordinate
MADE IN CANADA

MINISTRY OF THE ENVIRONMENT
Water Quantity Management Branch

TOWNSHIP OF GLOUCESTER
PIPER PLOT
Of well water samples
collected
on August 23, 1972

Date: 23/3/74

Scale:

Drawing No:

Prepared by: D.L.

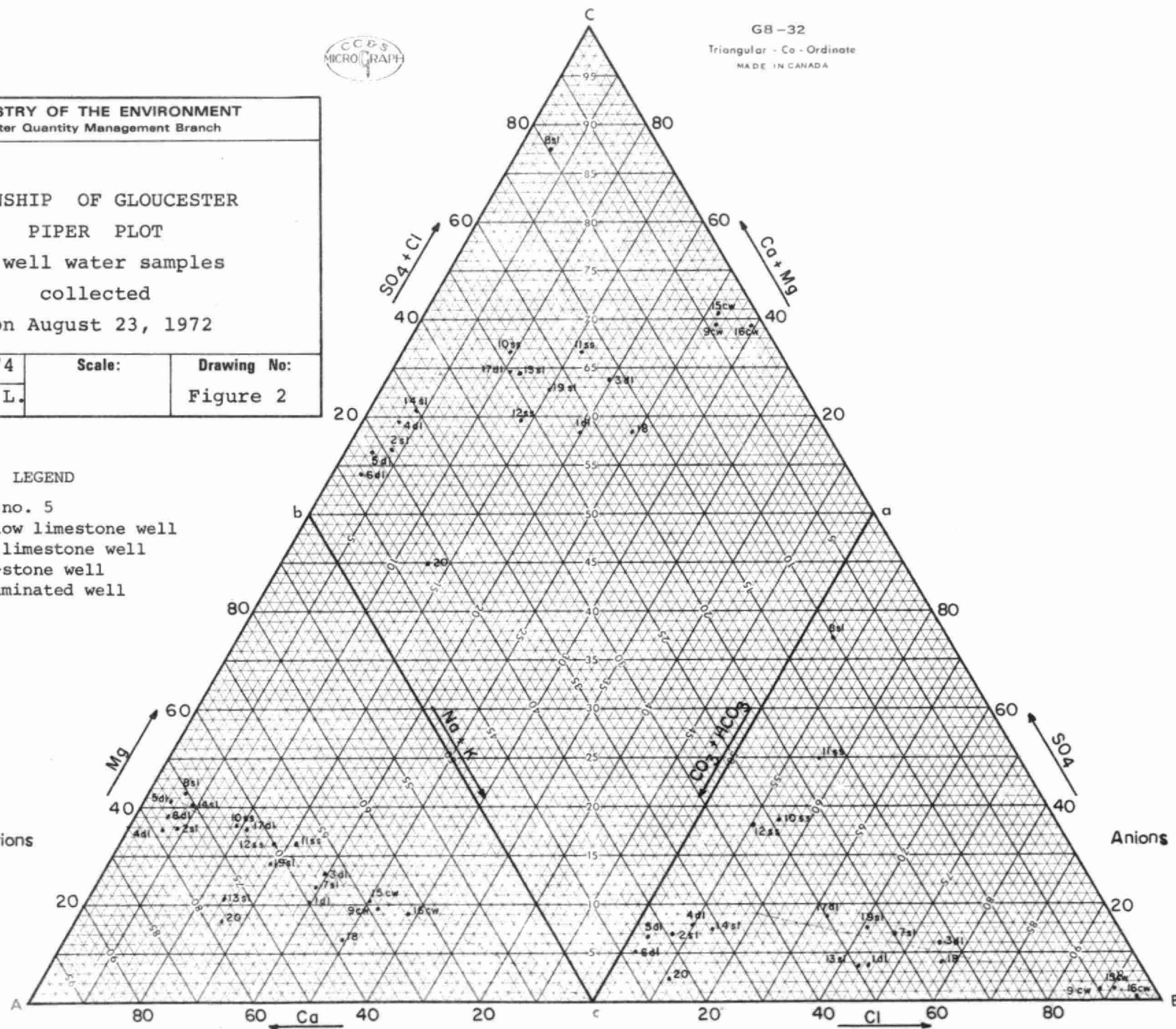
Figure 2

LEGEND

.5- well no. 5
sl- shallow limestone well
dl- deep limestone well
ss- sand-stone well
cw- contaminated well

Cations

Anions



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Table 1 Summary of Water Analyses

Prepared by:

Source	Location	Date Sampled	pH	BOD	Total Hardness as CaCO ₃ (ppm)	Alkalinity as CaCO ₃ (ppm)	Specific Conductance mmhos at 25°C	Chemical Constituents in parts per million (ppm)															
								Chloride (Cl)	Sulphate (SO ₄)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Nitrogen as N				Phosphorus as P				
															Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Tot.			Sol.	
W.A. WILSON	1	AUG 23/72			456	314		343	78		107	45	168	14									
F. DAoust	2	AUG 23/72			332	295		17	46		82	31	11	34									
P. MACKAY	3	AUG 23/72			592	338	5000 3650	407	120		139	67	180	9.9									
W. DAVIDSON	4	AUG. 23/72			400	311		27	62		101	36	6	7.7									
C. MOORE	5	AUG. 23/72			280	253		6	39		64	29	5	22									
M.G. OWEN	6	AUG. 23/72			348	331		11	26		82	34	4	5.7									
W.B. BAIRD	7	AUG. 23/72			532	335		281	117		133	48	143	22									
BERTRAND	8	AUG. 23/72			1030	216		39	790		224	114	27	6.8									
W. THEELAND DRILLED WELL	9	JULY 13/72			1860	282		2320	106	.20	480	160	865	23	.70	.82	.060	.04	.002				
		AUG 23/72			1560	287		2050	104		360	158	750	19									
		DEC. 6/72			2400	276	9900	3430	101	2.3	500	280	1250	32	1.0	1.3	.002	.01					
		MAY 16/73	7.3		1050	313	5400	1600	105	.65	232	115	765	18	.54	.70	.010	.01					

SEPT 23/74

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Table 1 Summary of Water Analyses

Prepared by:

Source	Location	Date Sampled	pH	BOD	Total Hardness as CaCO ₃ (ppm)	Alkalinity as CaCO ₃ (ppm)	Specific Conductance mmhos at 25°C	Chemical Constituents in parts per million (ppm)																
								Chloride (Cl)	Sulphate (SO ₄)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Nitrogen as N				Phosphorus as P					
															Free Ammonia	Total Kjeldahl	Nitrite	Nitrate	Total	Sol.				
BEAVER ASPHALT	10	AUG 23 72			452	277		56	208		101	48	44	5.7										
		MAY 16 73	7.3		432	270	980	97	126	.10	107	40	55	3.5	.03	.21	.005	.16						
MASTERLOY PRODUCTS	11	AUG 23 73						88	391		116	61	105	9.6										
		MAY 16 73	7.4		372	258	890	35	190	.20	82	41	52	6.8	.01	.20	.01	.87						
OTTAWA PRODUCTS	12	JULY 13 72			330	282		78	198	.15	77	33	115	7.2	6.0	6.4	.034	.01	1.9					
		AUG 23 72			324	242		30	161		72	35	51	5.8										
		MAY 16 73	7.4		376	274		70	210	.45	83	41	95	7.3	.01	.29	3.5	5.7						
P. MOROZUK	13	AUG 23 72			528	349		215	51		152	36	74	1.8										
M.G. OWEN TRAILER CAMP	14	AUG 23 72			344	282		37	58		77	36	13	4.5										
DOLSON	15	AUG 23 72			2040	290		2626	109		472	208	930	22										
CRUIKSHANK	16	AUG 23 72			3340	240		5620	113		736	360	2160	41										
		MAY 16 73	6.9		4300	237	18000	6440	100	.95	940	473	2330	31	1.6	1.8	.006	1.01						

SEP 23/74

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Table 1 Summary of Water Analyses

Prepared by:

[illegible]

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Table 1 Summary of Water Analyses

Prepared by:

[illegible]

TABLE 2

ONTARIO WATER RESOURCES COMMISSION

Page 1 of 2Area of Survey GLoucester TOWNSHIP

CHEMICAL BALANCE OF IONIC EQUIVALENTS

Date 23/8 19 72

CATIONS														ANIONS											
Ion	Ca			Mg			Na			K			Na+K	Total Cations	Alk as CaCO ₃			SO ₄			Cl			Total Anions	Diff %
Conversion Factor	ppm x .0499			ppm x .0822			ppm x .0435			ppm x .0256					HCO ₃ ppm x .0200 CO ₃ ppm x .5994	ppm x .0208			ppm x .0282						
Well No.	ppm	epm	%	ppm	epm	%	ppm	epm	%	ppm	epm	%		epm	ppm	epm	%	ppm	epm	%	ppm	epm	%	epm	
1	120	6	40	39	3.2	21	130	5.7	38	3.3	.08	1	39	15	358	7.16	48	57	1.2	8	230	6.5	44	14.9	0.7
2	82	4.1	56	31	2.6	36	11	.5	7	3.4	.09	1	8	7.3	295	5.9	80	46	1.0	14	17	0.5	7	7.4	1.4
3	139	7	34	67	5.5	27	180	7.8	38	9.9	.25	1	39	20.6	338	6.8	33	120	2.5	12	407	11.5	55	20.8	1.0
4	101	5	59	36	3.0	35	6	0.3	4	7.7	.20	2	6	8.5	311	6.22	75	62	1.3	16	27	0.8	10	8.3	2.4
5	64	3.2	54	29	2.4	41	5	0.2	3	2.2	.06	1	4	5.9	253	5.1	84	39	0.8	13	6	0.2	3	6.1	3.4
6	82	4.1	56	34	2.8	38	4	0.2	3	5.7	.15	2	5	7.3	331	6.6	89	26	0.5	7	11	0.3	4	7.4	1.4
7	133	6.6	38	48	4.0	23	143	6.2	36	22	.56	3	39	17.4	335	6.7	39	117	2.4	14	281	7.9	46	17.0	2.3
8	224	11.2	51	114	9.4	43	27	1.2	5	6.8	.17	1	6	22.0	216	4.3	20	790	16.4	75	39	1.1	5	21.8	0.9
9	360	18	28	158	13	20	750	32.6	51	19	.49	1	52	64.1	287	5.7	9	104	2.2	3	2050	57.8	88	65.7	2.5
10	101	5	45	48	4	36	44	1.9	17	5.7	.15	1	18	11.1	277	5.5	48	208	4.3	38	56	1.6	14	11.4	2.7
11	46	65.8	37	61	5	32	105	4.6	29	9.6	.25	2	31	15.7	278	5.6	35	391	8.1	50	88	2.5	15	16.2	3.2
12	72	3.6	40	35	2.9	33	51	2.2	25	5.8	.15	2	27	8.9	242	4.8	53	161	3.4	37	30	0.9	10	9.1	2.3
13	152	7.6	55	36	3	22	74	3.2	23	1.8	.05	1	24	13.9	349	7.0	49	51	1.1	8	215	6.1	43	14.2	2.2
14	77	3.8	51	36	3	40	13	0.6	8	4.5	.12	2	10	7.5	282	5.6	72	58	1.2	15	37	1.0	13	7.8	4.0
15	472	23.6	29	208	17.1	21	930	40.5	50	22	.56	1	51	81.8	290	5.8	7	109	2.3	3	2626	74.1	90	82.2	0.5

[Total Hardness as ppm CaCO₃ - (ppm Ca x 2.497)] x .243 = ppm MgBicarbonate alkalinity (HCO₃) as ppm CaCO₃ x 1.22 = ppm HCO₃ as HCO₃CO₃ as ppm CO₃ x .0333 = eppm CO₃HCO₃ as ppm HCO₃ x .0164 = eppm HCO₃

Area of Survey GLOUCESTER TOWNSHIP

CHEMICAL BALANCE OF IONIC EQUIVALENTS

Date 23/8 1972

[illegible]

Bicarbonate alkalinity (HCO_3^-) as ppm $\text{CaCO}_3 \times 1.22 = \text{ppm } \text{HCO}_3^- \text{ as } \text{HCO}_3^-$

$$\text{HCO}_3^- \text{ as ppm } \text{HCO}_3^- \times .0164 = \text{eqm } \text{HCO}_3^-$$